Wang 3-4
Ser. NO. 09/659879
Filed 9/12/00

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : H04Q 7/20

A2

(11) International Publication Number: WO 99/08460

(43) International Publication Date: 18 February 1999 (18.02.99)

(21) International Application Number: PCT/US98/16503

(22) International Filing Date: 7 August 1998 (07.08.98)

(30) Priority Data:
08/908,088 8 August 1997 (08.08.97) US

(71) Applicant: ERICSSON INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US).

(72) Inventor: RAMESH, Rajaram; 403 Danton Drive, Cary, NC 27511 (US).

(74) Agents: BIGEL, Mitchell, S. et al.; Myers, Bigel, Sibley & Sajovec, P.A., P.O. Box 37428, Raleigh, NC 27627 (US).

(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: COMMUNICATIONS APPARATUS AND METHODS FOR ADAPTIVE SIGNAL PROCESSING BASED ON MOBILITY CHARACTERISTICS

(57) Abstract

Information represented by a signal generated in a communications medium by a first entity is recovered by receiving the signal from the communications medium at a second entity, determining a mobility characteristic for communications between the first entity and the second entity, and adaptively estimating the information from the received signal based on the determined mobility characteristic. The mobility characteristic may be received from the first entity at the second entity, and the information represented by the received signal may be adaptively estimated based on the received mobility characteristic. According to an embodiment of the invention, the mobility characteristic is a cell type identifier which is communicated from a base station to a mobile terminal, the mobile terminal adaptively estimating information from a signal received from the base station based on the communicated cell type identifier. A number of signal processing functions may be adaptively performed, including adaptive demodulation, adaptive channel estimation/interpolation, adaptive equalization, adaptive channel tracking, and adaptive combining of received signals.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

COMMUNICATIONS APPARATUS AND METHODS FOR ADAPTIVE SIGNAL PROCESSING BASED ON MOBILITY CHARACTERISTICS

Field of the Invention

The present invention relates to communications systems and methods, in particular, to systems and methods for recovering information from signals generated in a communications medium.

Background of the Invention

Radiotelephone systems are commonly employed to provide voice and data communications to a plurality of mobile units or subscribers. For example, analog cellular radiotelephone systems, such as designated AMPS, ETACS, NMT-450, and NMT-900, have been deployed successfully throughout the world. More recently, digital cellular radiotelephone systems such as designated IS-54B in North America and the pan-European GSM system have been introduced. These systems, and others, are described, for example, in the book titled *Cellular Radio Systems* by Balston, et al., published by Artech House, Norwood, MA., 1993.

As illustrated in Figure 1, a conventional cellular communication system **20** includes one or more mobile terminals **10** which can communicate with one or more base stations **20** serving cells **30**. The base stations **20** are connected to a mobile telephone switching office (MTSO) **40**, which may in turn be connected to a public switched telephone network **50**. Although only two cells **20** are shown in Figure 1, a typical cellular network may include hundreds of base stations, thousands of mobile terminals and more than one MTSO. Each cell will have allocated to it one or more dedicated control channels and one or more voice channels. Through this cellular infrastructure, a communication link may be effected between two mobile terminals **10**, or between a mobile terminal **10** and a landline telephone **60**, with a base station **20** typically functioning as a relay station for data and voice information.

Components of a radio communications channel connecting a mobile terminal **10** and a base station **20** which can affect communications between the terminal **10** and the base station **20** include the communications medium, i.e., the atmospheric signal path across which radio communications signals are transmitted, which may introduce fading and interference into the radio communications signals. The fading may include long-term fading due to variations in terrain along the signal propagation path, as well as short-term multipath fading due to reflections from features such as buildings which cause fluctuations in received signal strength and other distortions at a receiving station. Mobile terrestrial radiotelephone communications are particularly susceptible to short-term multipath fading because the signal pathways tend to be close to the ground. Other elements which may have an effect on communications include transmitting and receiving components commonly found in base stations and mobile terminals, such as transmitters, receivers and antennas.

Various signal estimation techniques are conventionally employed to deal with signal degradation on a channel, including diversity reception, signal coding, and specialized demodulation techniques which produce estimates of a channel transfer characteristic. Diversity reception techniques included spatial diversity reception using multiple spaced apart receiving antennas, and polarization diversity reception using multiple antennas designed to accept electromagnetic signals having particular polarizations. As signals from diverse paths typically exhibit uncorrelated fading, they may be combined in the receiver to provide a more accurate estimate of information from a received signal. Signal coding schemes typically employ redundancy to enhance the accuracy of an estimate produced from a received signal, while channel estimation techniques such as pilot tone or symbol assisted modulation and demodulation can provide improved knowledge of a transfer characteristic for the channel to aid in estimating information from a received signal.

Despite the theoretical advantages of these estimation techniques, they may provide less than optimal communication under various propagation conditions encountered in a typical cellular communications system. Diversity reception may not provide sufficient gain because of limitations on antenna size, orientation, and placement, and may be ineffective or unnecessary at particular speeds or other

conditions. Coding schemes may entail an undesirable computational burden, while parameters used in estimating the channel may not be optimal for all mobile terminal speeds and under all delay spread conditions.

Summary of the Invention

In light of the foregoing, it is an object of the present invention to provide communications apparatus and methods which can provide improved signal estimation.

It is another object of the present invention to provide cellular communications apparatus and methods which can provide more optimal signal estimation under differing conditions of delay spread and terminal speed.

These and other objects, features and advantages are provided according to the present invention by communications apparatus and methods in which information is recovered at one entity, e.g., a mobile terminal, from a signal generated in a communications medium by another entity, e.g., a cellular base station, by adaptively estimating the information from the signal based on a mobility characteristic which characterizes communications between the entities. The process can be bidirectional, i.e., adaptive estimation of received signal may be performed at either end of a communications channel. The mobility characteristic may characterize mobility properties of the entities which affect signal propagation between the entities, such as relative speeds of the entities with respect to one another, range between the entities, and the like. According to one embodiment, the mobility characteristic includes a cell type identifier which characterizes mobility of mobile terminals with respect to a base station, e.g., an identifier which identifies a cell served by the base station as a highway macrocell, an urban macrocell, a microcell or the like, and which bears a correlation to aggregate speed and range properties for terminals typically found within the cell. The cell type identifier may be broadcast to mobile terminals from the base station over, for example, a broadcast control channel, and the mobile terminals can adaptively estimate information from signals received from the base station based on the broadcast cell type identifier. For example, the mobile terminal may store various signal processing elements such as channel estimators, channel interpolation

filters, channel trackers, and the like, as well as various parameters for such elements, and may apply these selected elements and parameters to a signal received from a base station based on a cell type identifier received from the station. Accordingly, more optimal signal estimation can be achieved by tailoring signal processing to the mobility characteristic.

In particular, according to the present invention, a communications system for communicating across a communications medium includes a first entity including means for generating a signal in the communications medium, the signal representing information, and a second entity including signal receiving means, responsive to the communications medium, for receiving a signal from the communications medium. The second also includes means for determining a mobility characteristic for communications between the first entity and the second entity, as well as adaptive estimating means, responsive to the signal receiving means, for adaptively estimating the information from the received signal based on the determined mobility characteristic.

According to one aspect of the present invention, the first entity further includes means for transmitting a mobility characteristic, and the means for determining a mobility characteristic includes means for receiving the transmitted mobility characteristic. The adaptive estimating means may include means for adaptively estimating the information based on the received mobility characteristic. The adaptive estimating means may include a number of different adaptive signal processing apparatus, including means for adaptively demodulating the received signal based on the determine mobility characteristic, means for adaptively estimating a characteristic for a channel connecting the first and second entities based on the determined mobility characteristic, means for selecting an interpolation filter based on the determined mobility characteristic, means for adaptively equalizing the received signal based on the determined mobility characteristic, means for adaptively tracking a channel connecting the base station and the mobile terminal based on the determined mobility characteristic, and means for adaptively combining a plurality of received signals based on the determined mobility characteristic.

According to an embodiment of the present invention, a cellular

communications system includes a base station, a mobile terminal, and means for communicating a mobility characteristic associated with communications of the base station and the terminal, between the base station and the terminal. A first one of the base station and the mobile terminal may include means for generating a signal in a communications medium, the generated signal representing information. A second one of the base station and the mobile terminal may include signal receiving means, responsive to the communications medium, for receiving the generated signal from the communications medium, and adaptive estimating means, responsive to the signal receiving means, for adaptively estimating the information from the received signal based on the received mobility characteristic. The means for communicating a mobility characteristic may include means for broadcasting a cell type identifier from the base station, for example, over a broadcast control channel. The means for communicating a mobility characteristic may also include means for communicating the mobility characteristic on a channel specific to the mobile terminal, such as an access grant channel or a fast associated control channel.

According to another aspect of the present invention, a communications terminal includes signal receiving means, responsive to a communications medium, for receiving a signal from the communications medium. Means are provided for determining a mobility characteristic associated with the communications medium, and adaptive estimating means are responsive to the signal receiving means and the mobility characteristic determining means, for adaptively estimating information from the received signal based on the determined mobility characteristic. The means for determining a mobility characteristic may include means for receiving a mobility characteristic, and the adaptive estimating means may adaptively estimate the information based on the received mobility characteristic.

According to method aspects of the present invention, information represented by a signal generated in a communications medium by a first entity is recovered by receiving the signal from the communications medium at a second entity, determining a mobility characteristic for communications between the first entity and the second entity, and adaptively estimating the information from the received signal based on the determined mobility characteristic. The mobility characteristic may be received

from the first entity at the second entity, and the information represented by the received signal may be adaptively estimated based on the received mobility characteristic. A number of signal processing functions may be adaptively performed, including adaptive demodulation, adaptive channel estimation/interpolation, adaptive equalization, adaptive channel tracking, and adaptive combining of received signals. Improved communications may thereby be achieved.

Brief Description of the Drawings

Some of the objects and advantages of the present invention having been stated, others will be more fully understood from the detailed description that follows and by reference to the accompanying drawings in which:

FIG. 1 is a schematic diagram illustrating a conventional cellular communications system;

FIGs. 2-3 are schematic diagrams illustrating embodiments of a cellular communications system according to the present invention;

FIGs. 4 is a schematic diagrams illustrating use of cell type identifier in embodiments of a cellular communications system according to the present invention;

FIG. 5 is a schematic diagram illustrating adaptive channel estimation according to the present invention;

FIG. 6 is a schematic diagram illustrating adaptive demodulation according to the present invention;

FIG. 7 is a schematic diagram illustrating adaptive signal combining according to the present invention; and

FIG. 8 is a flowchart illustration of operations for recovering information from a signal according to the present invention.

Detailed Description of Preferred Embodiments

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these

embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. In the drawings, like numbers refer to like elements throughout.

For purposes of the discussion herein, "estimation of information" from a signal refers generally to those operations commonly known as "signal estimation" or "signal processing" in which information is extracted from an electromagnetic signal used to represent the information, including, but not limited to, operations such as demodulation, filtering, sampling, equalizing and the like. In addition, "mobility characteristic" as referred to herein includes information relating to spatio-temporal relationships which may impact on communications between entities of a communications system. For example, in a cellular communications system in which mobile terminals communicate with base stations which serve geographical cells, a mobility characteristic may include information relating to spatial-temporal relationships between base stations and mobile terminals, such as speed or range of a specific mobile terminal or typical speed and range characteristics of a population of mobile terminals within a cell with respect to a base station serving the cell. The present invention arises from the realization that due to the effect these mobility characteristics can have on signal properties, e.g., delay spread, more optimal estimation of information from a signal received from a communications medium, e.g., more optimal signal processing, may be achieved by adaptively tailoring signal processing architectures and parameters to varying mobility characteristics.

FIG. 2 provides an illustration of a cellular communication system according to the present invention, including a base station **210** which includes means for generating a signal **215** in a communications medium, for example, a transmitter **202** generating a signal through a transmit antenna **204**. A mobile terminal **220** includes signal receiving means including, for example, a receive antenna **222**, for receiving the generated signal **215**. The received signal **223** is processed by adaptive estimating means **224** included in the mobile terminal **220**, based on a mobility characteristic **227** determined by mobility characteristic determining means **226**. As illustrated in FIG. 3, the roles of the base station **210** and the mobile terminal **220** may be reversed, with the base station **210** including signal receiving means, e.g, a base

ENSDOCID: <WO 9908460A2 |

station antenna **212** and associated hardware, for receiving a signal **211** generated by the mobile terminal **220**. Information **215** is adaptively estimated from the received signal **213** by adaptive estimating means **214**, based on a mobility characteristic **217** determined by mobility characteristic determining means **216** included in the base station **210**.

Those skilled in the art will appreciate that signal generating means of the base station **210** and the mobile terminal **220** may include, for example, commonly used communications components such as signal processors, coders, modulators, mixers, antennas, filters and the like, and may be implemented using special purpose hardware, software running on special or general purpose processors, and combinations thereof. Similarly, the signal receiving means described above may include such components as antennas, cables, waveguides, mixers, filters and the like. The mobility characteristic determining means **216, 226** and the adaptive estimating means **214, 224** described with respect to FIGs. 2-3 may be implemented using special purpose hardware, software running on general purpose processors such as a microprocessor, or combinations thereof. For example, the mobility characteristic determining means **216, 226** may include software running on a microprocessor which determines a mobility characteristic for communications between the base station **210** and the mobile terminal **220**, while a digital signal processing (DSP) chip or application specific integrated circuit (ASIC) may be used to implement functions of the adaptive estimating means **214, 224**, e.g., various signal processing tasks such as demodulation, channel estimation, and the like.

According to one embodiment of the invention, the mobility characteristic includes a cell type identifier which is communicated between a base station **410** and a mobile terminal **420**, as illustrated in FIG. 4. The cell type identifier may be communicated in a number of ways, included by broadcasting the cell type identifier from the base station **410** over a broadcast control channel **414**. The mobile terminal **420** may include means for receiving the broadcast cell type identifier **424**, such as receiver circuitry and associated elements which are commonly included in mobile terminals. Adaptive estimating means **422**, e.g., demodulating circuitry, signal processing circuitry and the like, are responsive to the cell type identifier receiving

means **424** for estimating information from a signal, for example, a signal received over a traffic channel **512**, for estimating information from the received signal based on the received cell type identifier **425**.

Tables I and II illustrate exemplary relationships mobility and signal characteristics associated with different cell types under the U.S. IS-136 and the European GSM standards, respectively, and desirable signal processing options for these conditions:

Table I: Signal Processing Options for IS-136 (and enhanced versions)

Cell Type	Typical Attributes	Signal processing options
Highway macrocell	High delay spread	Apply equalization
	High terminal speed	High speed channel tracking and channel interpolation
	High/Medium terminal speed	Disable diversity reception
Urban macrocell	Low delay spread	Differential detection or low-order equalizer (1 tap)
	Medium terminal speed	Medium speed channel tracking and channel interpolation
Microcell	Low delay spread	Differential detection or low order equalizer (1 tap)
	Low terminal speed	Low speed channel tracking and channel interpolation, enable diversity reception
Picocell	Low delay spread	Differential detection or low order equalizer
	Low speed	Low speed channel tracking and channel interpolation, enable diversity reception

Table II: Signal Processing Options for GSM

Cell Type	Typical Attributes	Signal processing options
Highway macrocell	High delay spread High terminal speed	High order equalizer Enable channel tracking
Urban macrocell	Low/Medium delay spread Medium terminal speed	Medium order equalizer (4 taps) Disable channel tracking
Microcell	Low/medium delay spread Low terminal speed	Low/medium order equalizer (3-4 taps) Disable channel tracking
Picocell	Low delay spread Low speed	Low order equalizer (3 taps) Disable channel tracking Low speed channel interpolation

Those skilled in the art will appreciate that other types of mobility characteristics and techniques for determining mobility characteristics for adaptive signal processing fall within the scope of the present invention. For example, instead of an indirect measurement of mobility which provides mobility information on a typical population of mobile terminals with respect to a base station, mobile-specific information such as the range and speed of a particular terminal may be determined. This information may also be communicated on a mobile-specific basis, instead of by broadcasting to a population of terminals on a common control channel. For example, a base station may compute range and speed for a terminal and transmit the computed information to the terminal on an access grant channel or fast associated control channel, and the mobile terminal may use this information to adaptively select from a "bank" of algorithms and/or algorithm parameters to optimally adapt its processing of signals received from the base station. In another implementation, a mobile terminal may include means for determining speed and range with respect to a particular base station with which it is communicating, and may use this information to adjust its signal processing. A base station could also perform similar computations to adjust its own signal processing.

An aspect of adaptive signal estimation according to the present invention is

illustrated in FIG. 5. In FIG. 5, an estimate **535** of symbols represented by a received signal **505** is produced in an adaptive fashion using a pilot-symbol assisted technique. Sampling means **510** produces a sequence of received symbols **515**. Pilot symbols **523** are extracted from the sequence **515** by decimating means **520**, and are passed to channel estimating means **560** and the channel interpolating means **540**. The channel interpolating means **540** interpolate a channel characteristic **545** for a channel over which the received signal **505** is received, e.g., a communications channel which connects a base station and a mobile terminal, using a channel interpolation filter **543** selected by interpolation filter selecting means **550** according to a mobility characteristic **547**. Symbol estimating means **530** estimate the original symbol sequence represented by the received signal **505**, using the interpolated channel characteristic **545**.

Those skilled in the art will appreciate that the means of FIG. 5 may be implemented using a variety of commonly-used communications components, including special purpose hardware, software or firmware running on a data processing apparatus or combinations thereof. For example, sampling means **510** may include analog-to-digital converters (A/Ds), associated filters, and the like. The functions of interpolation filter selecting means **550** may, for example, be performed by a control microprocessor or similar apparatus, while the functions of decimating means **520**, channel interpolating means **540** and symbol estimating means **530** may be performed by a DSP, ASIC or the like. The operations of these components is well-known to those skilled in the art, and will not be discussed in detail herein.

Other adaptive signal processing aspects are illustrated in FIGs. 6 and 7. In FIG. 6, a received signal **605** is adaptively demodulated according to a mobility characteristic **607**. Demodulating means **610** may include adaptive equalizing means **612** which equalizes the received signal **605** according to the mobility characteristic **607** for subsequent detection in detecting means **616**. The embodiment illustrated in FIG. 6 includes equalizing means **612**, which includes adaptive channel tracking means **614** which tracks a channel over which the signal **605** is received, based on the mobility characteristic **607**.

In FIG. 7, a plurality of signals **715a-d** are received from a plurality of signal

paths, for example, using a plurality of spatially diverse antennas **710a-d**. Signal combining means **720** combines the plurality of signals **715a-d** according to a mobility characteristic **717**, producing a combined signal **725**. Those skilled in the art will appreciate that under certain mobility characteristics, diversity combination of signals may be unnecessary, and that combining of diversely received signals may consist of selecting a single one of the signals for processing, for example, a signal having the highest signal strength.

Those skilled in the art will appreciate that the means described with respect to FIGs. 6 and 7 may implemented using various commonly-used communications components, including special purpose hardware, software or firmware running on a general purpose data processing apparatus, or combinations thereof. For example, the functions of the adaptive demodulating means **610** and the signal combining means **720** may be performed by a DSP, ASIC or similar circuits.

Exemplary operations for recovering information from a signal generated in a communications medium according to the present invention are illustrated in FIG. 8 (Block **800**). To recover information from a signal generated in a communications medium, for example, a signal generated by a base station of a cellular communications system, a mobility characteristic is determined, e.g., a cell type identifier is received from the base station (Block **810**). A signal generated by the based station is received (Block **820**), and information represented by the signal is adaptively estimated according to the received mobility characteristic. For example, a channel characteristic may be selected for the channel over which the signal is received based on the received cell type identifier (Block **830**), and information may be estimated from the received signal based on the selected channel characteristic (Block **840**). Those skilled in the art will appreciate that numerous variations on the above-described operations also fall within the scope of the present invention, including variations on the type of mobility characteristic employed, the manner in which the mobility characteristic is determined, and the type of adaptive signal estimation performed. In the drawings and specification, there have been disclosed typical embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for purposes

of limitation, the scope of the invention being set forth in the following claims.

THAT WHICH IS CLAIMED IS:

1. A communications system, comprising:

a first entity including means for generating a signal in a communications medium, the signal representing information; and

a second entity including:

signal receiving means, responsive to the communications medium, for receiving a signal from the communications medium;

means for determining a mobility characteristic for communications between the first entity and the second entity; and

adaptive estimating means, responsive to said signal receiving means, for adaptively estimating the information from the received signal based on the determined mobility characteristic.

2. A system according to Claim 1:

wherein said first entity further comprises means for transmitting a mobility characteristic;

wherein said means for determining a mobility characteristic comprises means for receiving the transmitted mobility characteristic; and

wherein said adaptive estimating means comprises means for adaptively estimating the information based on the received mobility characteristic.

3. A system according to Claim 1, wherein a first one of the first and second entities comprises a cellular base station, and wherein said mobility characteristic characterizes mobility with respect to the cellular base station.

4. A system according to Claim 3, wherein the base station serves a cell, and wherein said mobility characteristic characterizes mobility of mobile terminals which typically are present in said cell.

5. A system according to Claim 4, wherein said mobility characteristic comprises a cell type identifier.

6. A system according to Claim 3, wherein a second one of the first and second entities comprises a mobile terminal, and wherein said mobility characteristic characterizes mobility of said mobile terminal with respect to said cellular base station.

7. A system according to Claim 1, wherein said adaptive estimating means comprises means for adaptively demodulating the received signal based on the determined mobility characteristic.

8. A system according to Claim 1, wherein said adaptive estimating means comprises:

means for adaptively estimating a characteristic for a channel connecting the first and second entities based on the determined mobility characteristic; and

means for estimating the information from the received signal based on the estimated channel characteristic.

9. A system according to Claim 8, wherein the signal represents a symbol sequence including a pilot symbol, and wherein said adaptive estimating means comprises:

means, responsive to said signal receiving means, for detecting a pilot symbol from the received signal;

means, responsive to said means for determining a mobility characteristic, for selecting an interpolation filter based on the determined mobility characteristic;

means, responsive to said means for detecting a pilot symbol and to said means for selecting an interpolation filter, for interpolating a characteristic for the channel from the detected pilot symbol according to the selected interpolation filter; and

means, responsive to said means for interpolating a channel characteristic, for estimating the symbol sequence from the received signal based on the interpolated channel characteristic.

10. A system according to Claim 1, wherein said adaptive estimating means comprises means for adaptively equalizing the received signal based on the determined mobility characteristic.

11. A system according to Claim 10, wherein said means for adaptively equalizing comprises means for adaptively tracking a channel connecting the base station and the mobile terminal based on the determined mobility characteristic.

12. A system according to Claim 1:

wherein said signal receiving means comprises means for receiving a plurality of signals over a plurality of signal paths; and

wherein said adaptive estimating means comprises means for adaptively combining the plurality of signals based on the determined mobility characteristic.

13. A cellular communications system, comprising:

a base station;

a mobile terminal; and

means for communicating a mobility characteristic associated with communications of said base station and said terminal, between said base station and said terminal,

wherein a first one of said base station and said mobile terminal includes means for generating a signal in a communications medium, the generated signal representing information; and

wherein a second one of said base station and said mobile terminal includes:

signal receiving means, responsive to the communications medium, for receiving the generated signal from the communications medium; and

adaptive estimating means, responsive to said signal receiving means, for adaptively estimating the information from the received signal based on the received mobility characteristic.

14. A system according to Claim 13, wherein said base station serves a cell, and wherein said means for communicating a mobility characteristic comprises means for broadcasting a cell type identifier from said base station.

15. A system according to Claim 14, wherein said means for broadcasting comprises means for broadcasting the cell type identifier on a broadcast control channel.

16. A system according to Claim 13, wherein said means for communicating a mobility characteristic comprises means for communicating the mobility characteristic on a channel specific to the mobile terminal.

17. A system according to Claim 16, wherein said means for communicating transmitting a mobility characteristic comprises means for communicating the mobility characteristic on an access grant channel.

18. A system according to Claim 16, wherein said means for communicating a mobility characteristic comprises means for communicating the mobility characteristic on a fast associated control channel.

19. A system according to Claim 13, wherein said adaptive estimating means comprises means for adaptively demodulating the received signal based on the received mobility characteristic.

20. A system according to Claim 13, wherein said adaptive estimating means comprises:

means for adaptively estimating a characteristic for a channel connecting the base station and the mobile terminal based on the received mobility characteristic; and

means, responsive to said means for adaptively estimating a channel characteristic, for estimating the information based on the estimated channel characteristic.

21. A system according to Claim 20, wherein the information includes a symbol sequence including a pilot symbol, and wherein adaptive estimating means comprises:

means, responsive to said signal receiving means, for detecting a pilot symbol from the received signal;

means, responsive to said means for receiving a mobility characteristic, for selecting an interpolation filter based on the received mobility characteristic;

means, responsive to said means for selecting an interpolation filter, for interpolating a characteristic for the channel from the detected pilot symbol according to the selected interpolation filter; and

means, responsive to said means for interpolating a channel characteristic, for estimating the symbol sequence from the received signal based on the interpolated channel characteristic.

22. A system according to Claim 13, wherein said adaptive estimating means comprises means for adaptively equalizing the received signal based on the received mobility characteristic.

23. A system according to Claim 22, wherein said means for adaptively equalizing comprises means for adaptively tracking a channel connecting the base station and the mobile terminal based on the received mobility characteristic.

24. A system according to Claim 13:

wherein said signal receiving means comprises means for receiving a plurality of signals over a plurality of signal paths; and

wherein said adaptive estimating means comprises means for adaptively combining the plurality of signals based on the received mobility characteristic.

25. A communications terminal, comprising:

signal receiving means, responsive to a communications medium, for

receiving a signal from a communications medium;

means for determining a mobility characteristic associated with the communications medium; and

adaptive estimating means, responsive to said signal receiving means, for adaptively estimating information from the received signal based on the determined mobility characteristic.

26. A terminal according to Claim 25:

wherein said means for determining a mobility characteristic comprises means for receiving a mobility characteristic; and

wherein said adaptive estimating means comprises means for adaptively estimating the information based on the received mobility characteristic.

27. A terminal according to Claim 26, wherein said means for receiving a mobility characteristic comprises means for receiving a mobility characteristic which characterizes mobility with respect to a cellular base station.

28. A terminal according to Claim 27, wherein said means for receiving a mobility characteristic comprises means for receiving a cell type identifier.

29. A terminal according to Claim 25, wherein said adaptive estimating means comprises means for adaptively demodulating the received signal based on the determined mobility characteristic.

30. A terminal according to Claim 25, wherein the communications medium includes a channel and wherein said adaptive estimating means comprises:

means for adaptively estimating a channel characteristic for the channel based on the determined mobility characteristic; and

means, responsive to said means for estimating a channel characteristic, for estimating the information from the received signal based on the estimated channel characteristic.

RNSDOCID: <WO 9908460A2 | >

31. A terminal according to Claim 30, wherein said adaptive estimating means comprises:

means, responsive to said signal receiving means, for detecting a pilot symbol from the received signal;

means, responsive to said means for determining a mobility characteristic, for selecting an interpolation filter based on the determined mobility characteristic;

means, responsive to said means for detecting a pilot symbol and to said means for selecting and interpolation filter, for interpolating the channel characteristic for the channel from the detected pilot symbol and the selected interpolation filter; and

means, responsive to said means for interpolating a channel characteristic, for estimating a symbol sequence from the received signal based on the interpolated channel characteristic.

32. A terminal according to Claim 25, wherein said adaptive estimating means comprises means for adaptively equalizing the received signal based on the determined mobility characteristic.

33. A terminal according to Claim 32, wherein said means for adaptively equalizing comprises means for adaptively tracking a channel associated with the communications medium based on the determined mobility characteristic.

34. A terminal according to Claim 25:

wherein signal receiving means comprises means for receiving a plurality of signals; and

wherein said adaptive estimating means comprises means for adaptively combining the plurality of received signals based on the determined mobility characteristic.

35. A method of recovering information represented by a signal generated in a communications medium by a first entity, the method comprising the steps of:

receiving the signal from the communications medium at a second entity;

determining a mobility characteristic for communications between the first entity and the second entity; and

adaptively estimating the information from the received signal based on the determined mobility characteristic.

36. A method according to Claim 35:

wherein said step of determining a mobility characteristic comprises the step of receiving a mobility characteristic from the first entity at the second entity; and

wherein said step of adaptively estimating comprises the step of adaptively estimating the information at the second entity based on the received mobility characteristic.

37. A method according to Claim 35, wherein a first one of the first and second entities comprises a cellular base station, and wherein the mobility characteristic characterizes mobility with respect to the cellular base station.

38. A method according to Claim 37, wherein the communicated mobility characteristic characterizes mobility of mobile terminals which typically are present in a cell served by the base station.

39. A method according to Claim 38, wherein the communicated mobility characteristic comprises a cell type identifier.

40. A method according to Claim 37, wherein a second one of the first and second entities comprises a mobile terminal and wherein the mobility characteristic characterizes mobility of the mobile terminal with respect to the cellular base station.

41. A method according to Claim 35, wherein said step of adaptively estimating comprises the step of adaptively demodulating the received signal based on the determined mobility characteristic.

42. A method according to Claim 35, wherein said step of adaptively estimating comprises the steps of:

adaptively estimating a characteristic for a channel connecting the first and second entities based on the determined mobility characteristic; and

estimating the information based on the estimated channel characteristic.

43. A method according to Claim 42, wherein the information includes a symbol sequence including a pilot symbol, and wherein said step of adaptively estimating the information comprises the steps of:

detecting a pilot symbol from the received signal;

selecting an interpolation filter based on the determined mobility characteristic;

interpolating a characteristic for the channel from the detected pilot symbol according to the selected interpolation filter; and

estimating the symbol sequence from the received signal based on the interpolated channel characteristic.

44. A method according to Claim 35, wherein said step of adaptively estimating comprises the step of adaptively equalizing the received signal based on the determined mobility characteristic.

45. A method according to Claim 44, wherein said step of adaptively equalizing comprises the step of adaptively tracking a channel connecting the first and second entities based on the determined mobility characteristic.

46. A method according to Claim 35:

wherein said step of receiving a signal comprises the step of receiving a plurality of signals over a plurality of signal paths; and

wherein said step of adaptively estimating comprises the step of combining the plurality of signals based on the determined mobility characteristic.

47. A method of communicating information between a mobile terminal and a base station which serves a cell of a cellular communications system, the method comprising the steps of:

communicating a mobility characteristic associated with communications between the base station and the mobile terminal between the base station and the mobile terminal;

generating a signal in a communications medium from a first one of the base station and the mobile terminal, the signal representing information;

receiving the generated signal from the communications medium at a second one of the base station and the mobile terminal; and

generating an estimate of the information from the received signal based on the communicated mobility characteristic.

48. A method according to Claim 47, wherein said step of communicating a mobility characteristic comprises the step of broadcasting a cell type identifier from the base station.

49. A method according to Claim 48, wherein said step of broadcasting comprises the step of communicating the mobility characteristic on a broadcast control channel.

50. A method according to Claim 47, wherein said step of communicating a mobility characteristic comprises the step of communicating the mobility characteristic on a channel assigned to one mobile terminal.

51. A method according to Claim 50, wherein said step of communicating the mobility characteristic comprises the step of communicating the mobility characteristic on an access grant channel.

52. A method according to Claim 50, wherein said step of communicating the mobility characteristic comprises the step of communicating the mobility

characteristic on a fast associated control channel.

53. A method according to Claim 47, wherein said step of adaptively estimating comprises the step of adaptively demodulating the received signal based on the communicated mobility characteristic.

54. A method according to Claim 47, wherein said step of adaptively estimating comprises the steps or:

adaptively estimating a characteristic for a channel connecting the base station and the mobile terminal based on the communicated mobility characteristic; and

estimating the information based on the estimated channel characteristic.

55. A method according to Claim 54, wherein the information includes a symbol sequence including a pilot symbol, and wherein said step of adaptively estimating the information comprises the steps of:

detecting a pilot symbol from the received signal;

selecting an interpolation filter based on the communicated mobility characteristic;

interpolating a characteristic for the channel from the detected pilot symbol according to the selected interpolation filter; and

estimating the symbol sequence from the received signal based on the interpolated channel characteristic.

56. A method according to Claim 47, wherein said step of adaptively estimating comprises the step of adaptively equalizing the received signal based on the communicated mobility characteristic.

57. A method according to Claim 56, wherein said step of adaptively equalizing comprises the step of adaptively tracking a channel connecting the base station and the mobile terminal based on the communicated mobility characteristic.

58. A method according to Claim 47:

wherein said step of receiving a signal comprises the step of receiving a plurality of signals over a plurality of signal paths; and

wherein said step of adaptively estimating comprises the step of adaptively combining the plurality of signals based on the communicated mobility characteristic.

FIG. 1

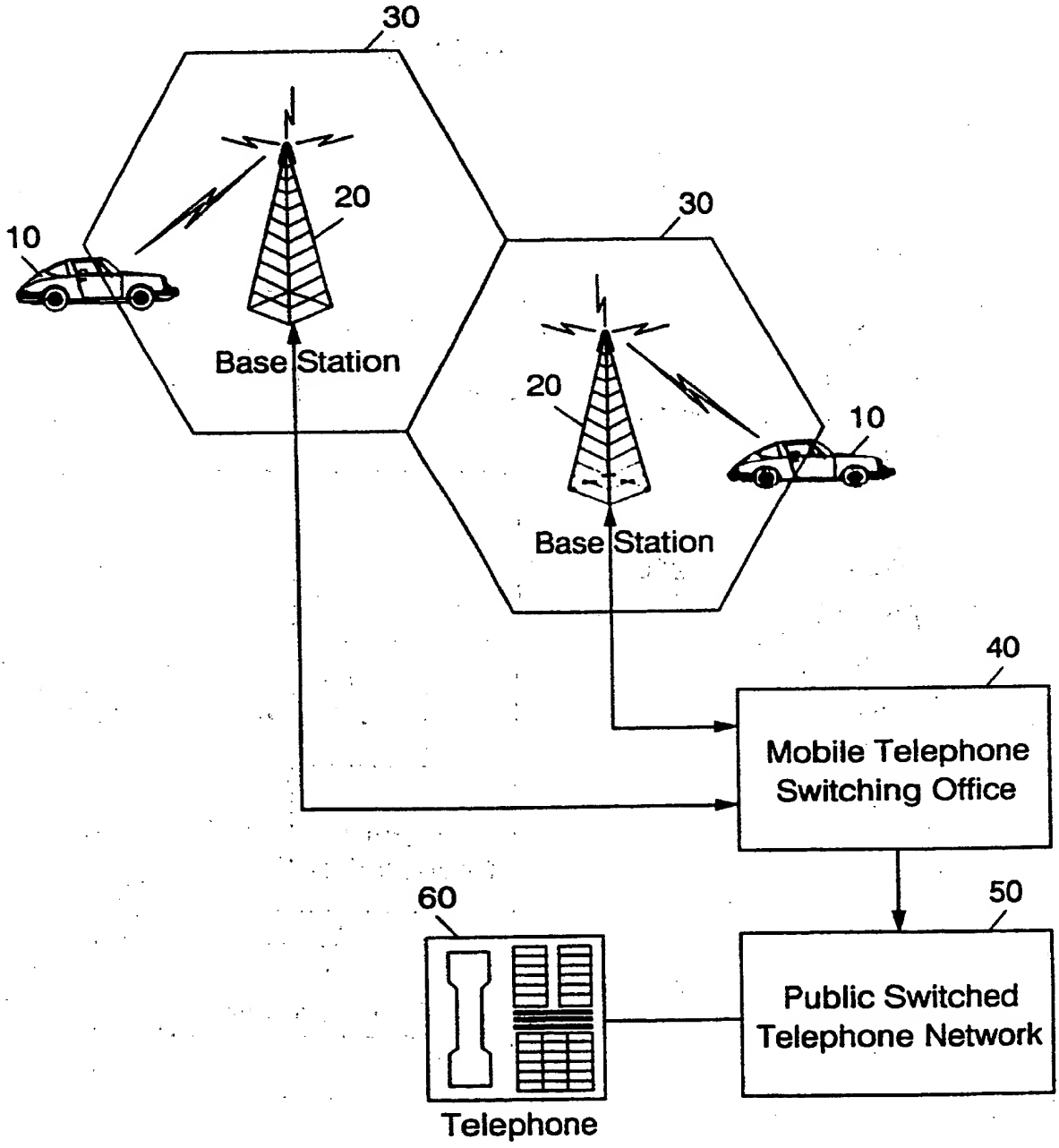

30
20
10
Base Station
30
20
10
Base Station
40
Mobile Telephone Switching Office
60
50
Public Switched Telephone Network
Telephone

FIG. 2

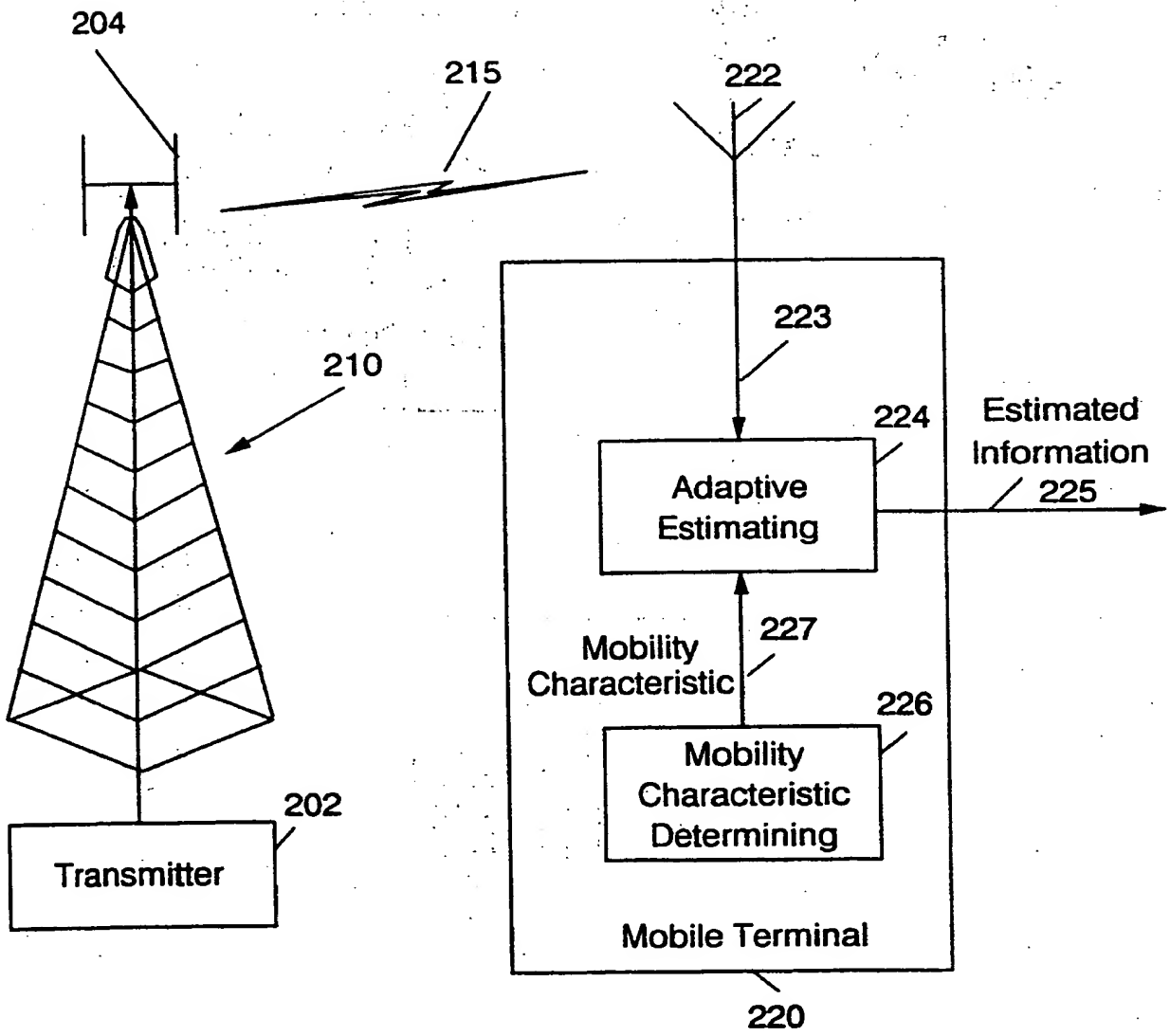

204
215
222
223
210
224
Estimated
Information
225
Adaptive
Estimating
227
Mobility
Characteristic
226
Mobility
Characteristic
Determining
202
Transmitter
Mobile Terminal
220

FIG. 3

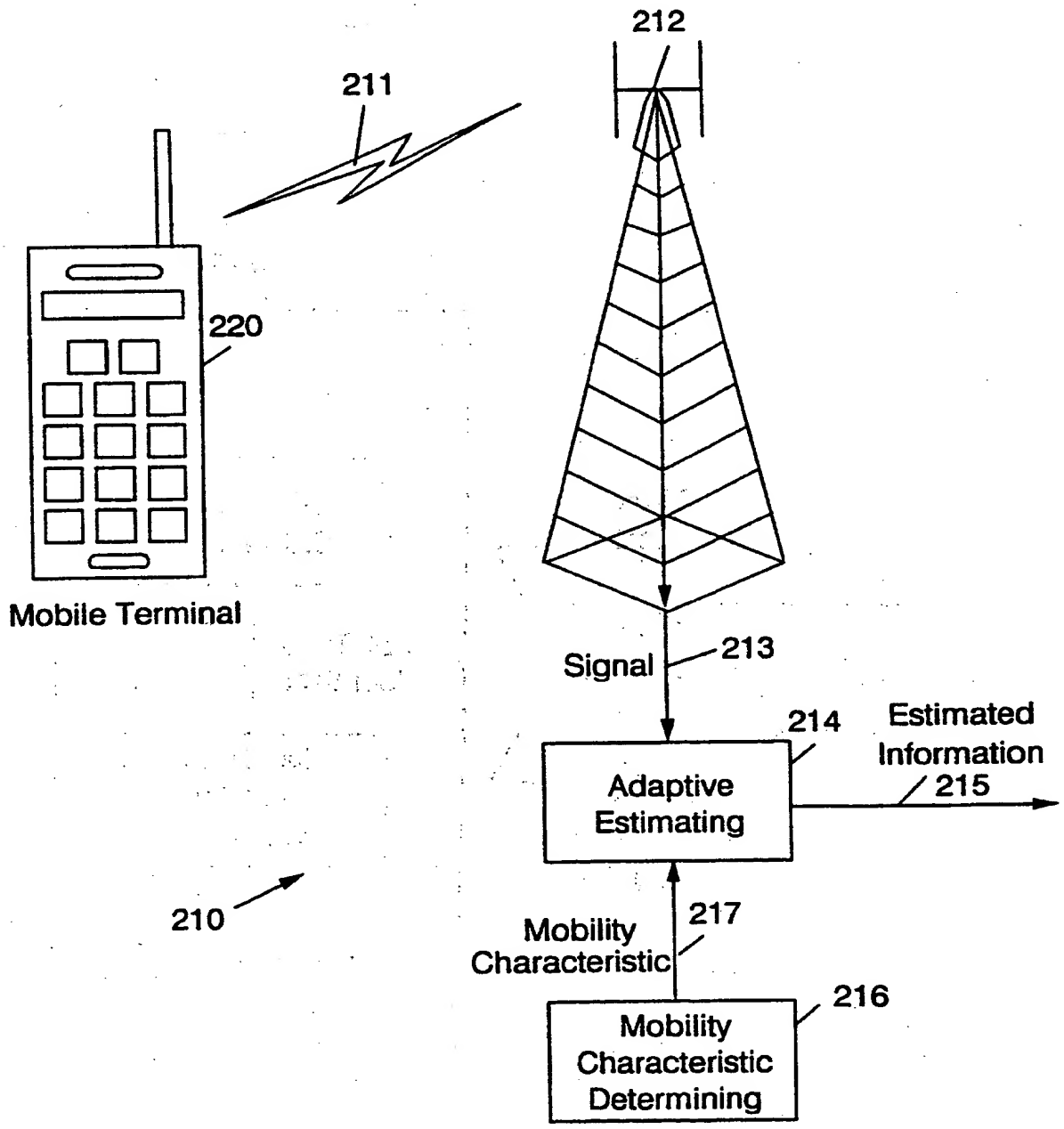
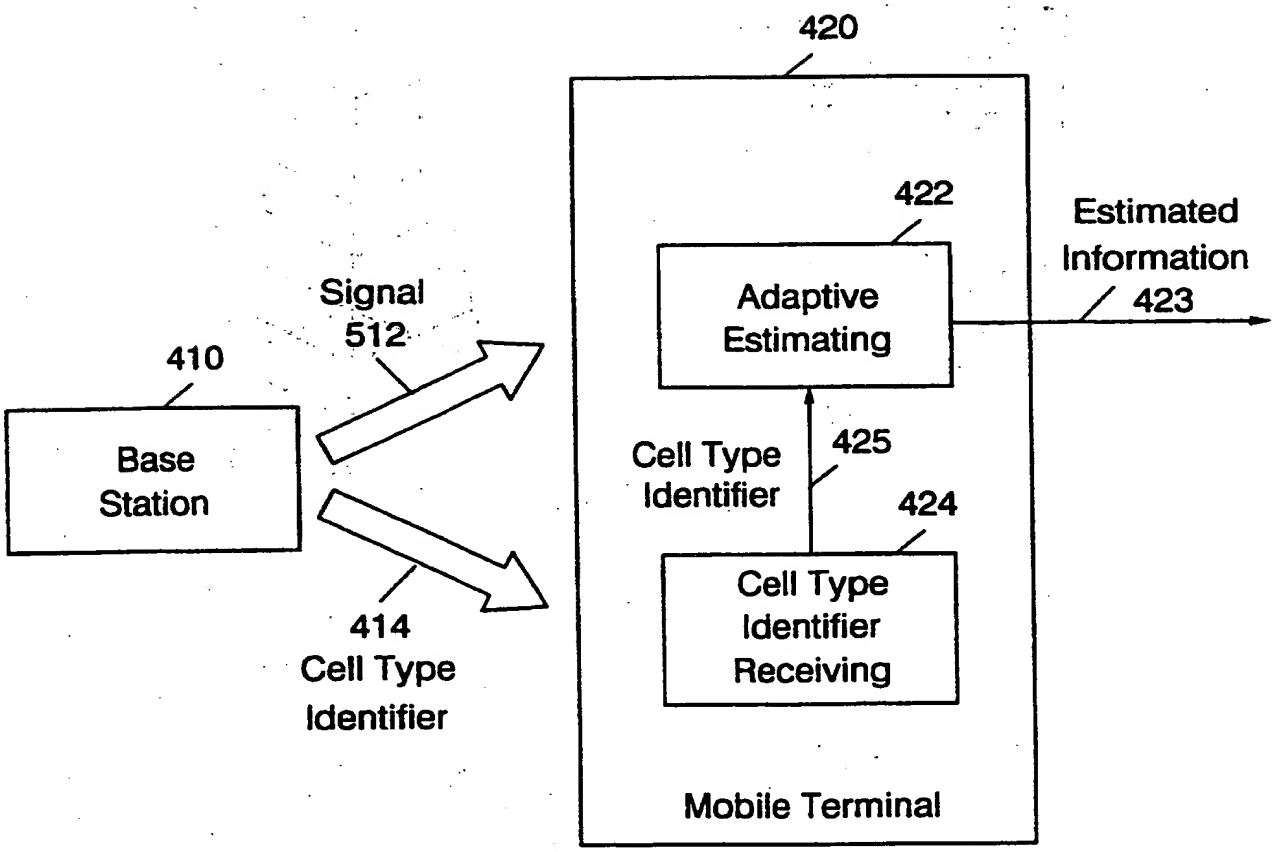

212
211
220
Mobile Terminal
Signal
213
214
Estimated
Information
215
Adaptive
Estimating
210
Mobility
Characteristic
217
216
Mobility
Characteristic
Determining

FIG. 4



BNSDOCID: <WO 9908460A2 | >

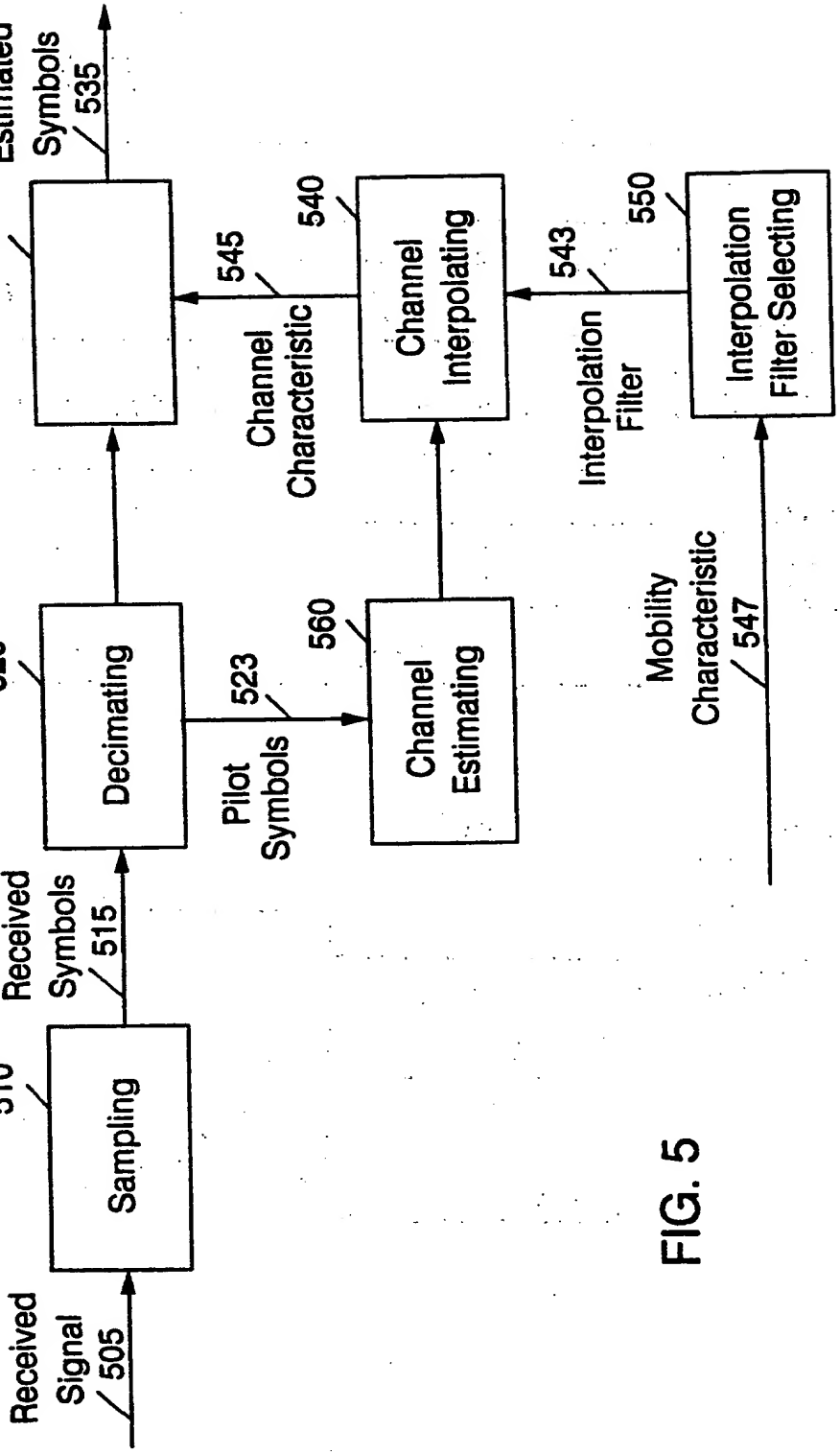

Received Signal 505
510
Sampling
Received Symbols 515
520
Decimating
523
Pilot Symbols
560
Channel Estimating
Mobility Characteristic 547
550
Interpolation Filter Selecting
543
Interpolation Filter
540
Channel Interpolating
545
Channel Characteristic
530
Estimated Symbols 535

FIG. 5

FIG. 6

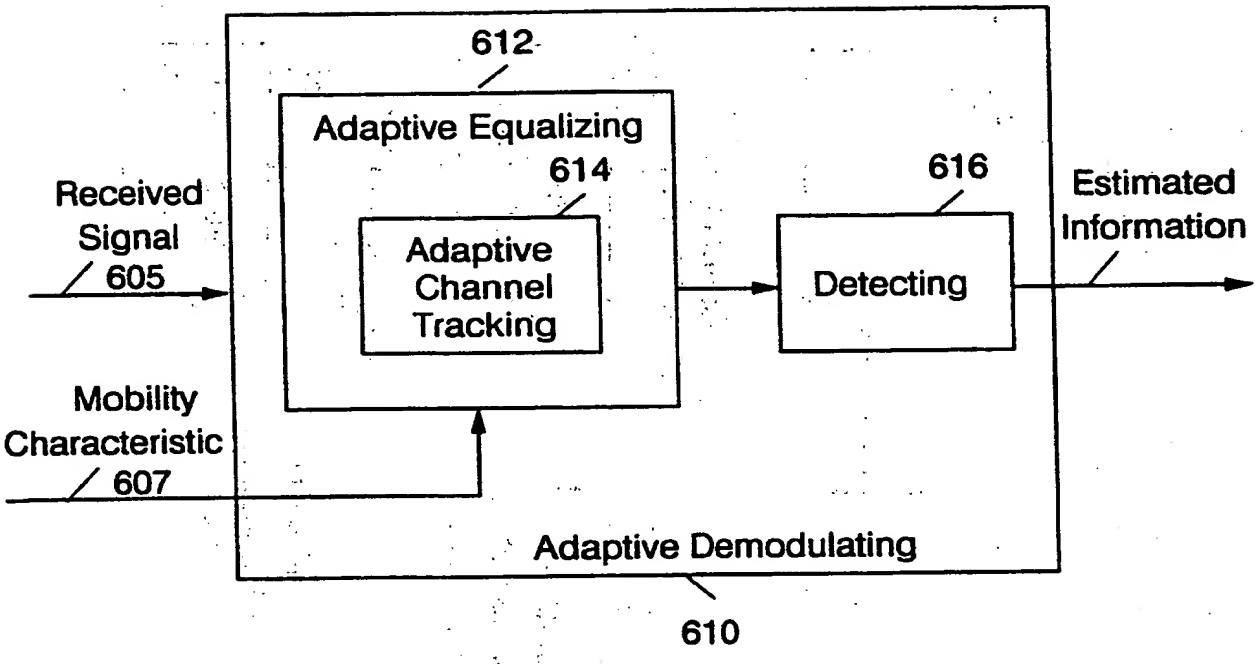
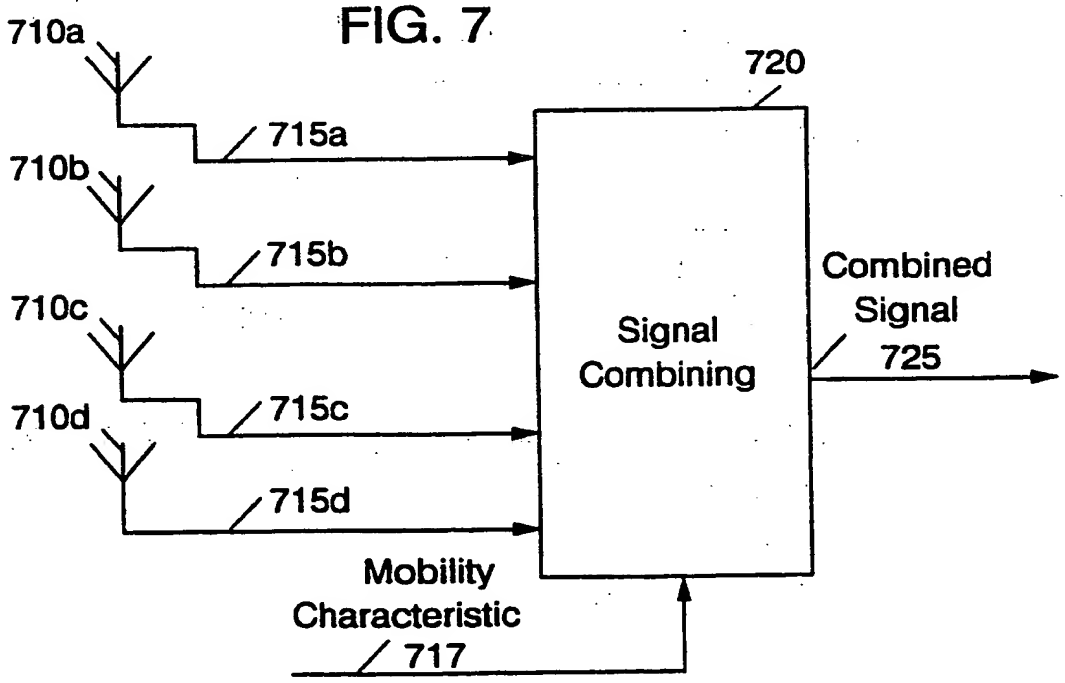
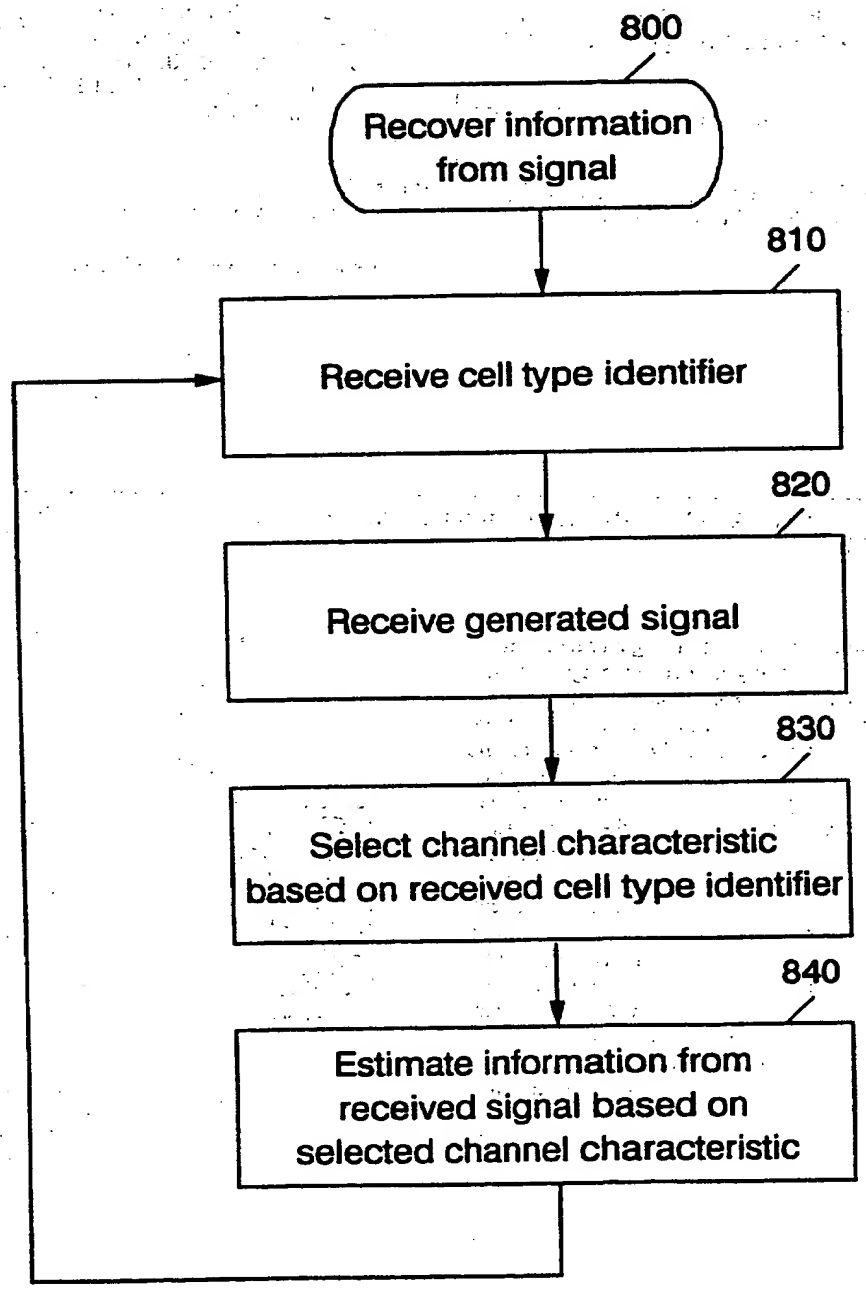


FIG. 7



BNSDOCID: <WO 9908460A2 I >

FIG. 8


800
Recover information from signal
810
Receive cell type identifier
820
Receive generated signal
830
Select channel characteristic based on received cell type identifier
840
Estimate information from received signal based on selected channel characteristic

PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : **H04B 7/005, 17/00** | **A3**

(11) International Publication Number: **WO 99/08460**

(43) International Publication Date: 18 February 1999 (18.02.99)

(21) International Application Number: PCT/US98/16503

(22) International Filing Date: 7 August 1998 (07.08.98)

(30) Priority Data:
08/908,088 8 August 1997 (08.08.97) US

(71) Applicant: ERICSSON INC. [US/US]; 7001 Development Drive, P.O. Box 13969, Research Triangle Park, NC 27709 (US).

(72) Inventor: RAMESH, Rajaram; 403 Danton Drive, Cary, NC 27511 (US).

(74) Agents: BIGEL, Mitchell, S. et al.; Myers, Bigel, Sibley & Sajovec, P.A., P.O. Box 37428, Raleigh, NC 27627 (US).

(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

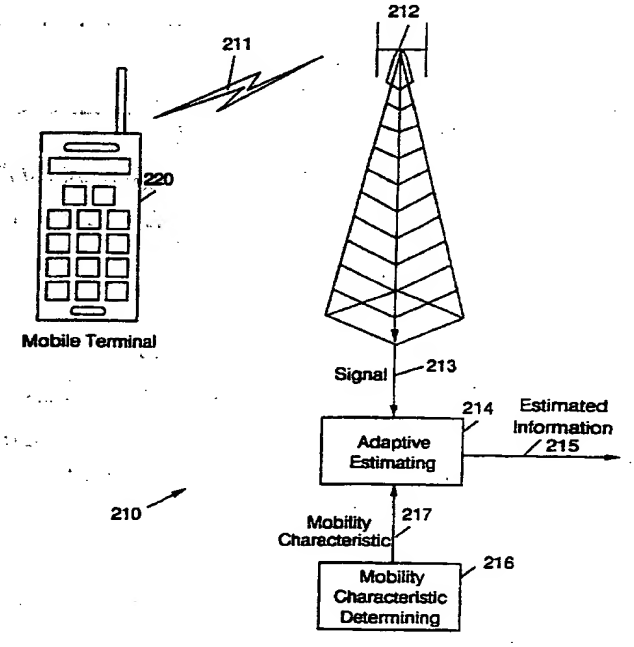
Published
With international search report.

(88) Date of publication of the international search report:
3 June 1999 (03.06.99)

(54) Title: COMMUNICATIONS APPARATUS AND METHODS FOR ADAPTIVE SIGNAL PROCESSING BASED ON MOBILITY CHARACTERISTICS

(57) Abstract

Information represented by a signal generated in a communications medium by a first entity is recovered by receiving the signal from the communications medium at a second entity, determining a mobility characteristic for communications between the first entity and the second entity, and adaptively estimating the information from the received signal based on the determined mobility characteristic. The mobility characteristic may be received from the first entity at the second entity, and the information represented by the received signal may be adaptively estimated based on the received mobility characteristic. According to an embodiment of the invention, the mobility characteristic is a cell type identifier which is communicated from a base station to a mobile terminal, the mobile terminal adaptively estimating information from a signal received from the base station based on the communicated cell type identifier. A number of signal processing functions may be adaptively performed, including adaptive demodulation, adaptive channel estimation/interpolation, adaptive equalization, adaptive channel tracking, and adaptive combining of received signals.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania
AM	Armenia
AT	Austria
AU	Australia
AZ	Azerbaijan
BA	Bosnia and Herzegovina
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CU	Cuba
CZ	Czech Republic
DE	Germany
DK	Denmark
EE	Estonia
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GH	Ghana
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IL	Israel
IS	Iceland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgyzstan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakstan
LC	Saint Lucia
LI	Liechtenstein
LK	Sri Lanka
LR	Liberia
LS	Lesotho
LT	Lithuania
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
MK	The former Yugoslav Republic of Macedonia
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
MX	Mexico
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SG	Singapore
SI	Slovenia
SK	Slovakia
SN	Senegal
SZ	Swaziland
TD	Chad
TG	Togo
TJ	Tajikistan
TM	Turkmenistan
TR	Turkey
TT	Trinidad and Tobago
UA	Ukraine
UG	Uganda
US	United States of America
UZ	Uzbekistan
VN	Viet Nam
YU	Yugoslavia
ZW	Zimbabwe

INTERNATIONAL SEARCH REPORT

Intern ial Application No
PCT/US 98/16503

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H04B7/005 H04B17/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	LI H ET AL: "AN ADAPTIVE FILTERING TECHNIQUE FOR PILOT AIDED TRANSMISSION SYSTEMS" VEHICULAR TECHNOLOGY CONFERENCE, ORLANDO, MAY 6 - 9, 1990, no. CONF. 40, 6 May 1990, pages 507-512, XP000204166 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS see the whole document --- -/--	1-4, 6-13,16, 19-27, 29-38, 40-47, 50-58

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
19 March 1999	26/03/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Cochonneau, O

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Interr nal Application No
PCT/US 98/16503

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 0 496 677 A (FUJITSU LTD) 29 July 1992 see abstract see page 2, line 13 - line 58 see page 4, line 52 - page 6, line 42 see figures 2-7,12,21,23	1,13,25, 35,47 2-12, 14-24, 26-34, 36-46, 48-58
A	EP 0 434 651 A (ERICSSON TELEFON AB L M) 26 June 1991 see abstract see column 2, line 38 - column 3, line 44 see column 3, line 24 - column 9, line 16 see figures 6-8	1-58
A	EP 0 593 186 A (NOKIA MOBILE PHONES LTD) 20 April 1994 see abstract see page 2, line 13 - page 3, line 49 see figure 2	1-58

1

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter nal Application No
PCT/US 98/16503

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0496677 A	29-07-1992	DE 69220683 D	14-08-1997
		DE 69220683 T	06-11-1997
		JP 2031702 C	19-03-1996
		JP 5048391 A	26-02-1993
		JP 7070970 B	31-07-1995
		US 5434883 A	18-07-1995
EP 0434651 A	26-06-1991	SE 465245 B	12-08-1991
		AU 630537 B	29-10-1992
		AU 6972891 A	24-07-1991
		CA 2046316 A	23-06-1991
		DE 69006586 D	24-03-1994
		DE 69006586 T	26-05-1994
		HK 85494 A	26-08-1994
		JP 4504943 T	27-08-1992
		KR 9707616 B	13-05-1997
		SE 8904327 A	23-06-1991
		WO 9110296 A	11-07-1991
		SG 92594 G	16-06-1995
		US 5204878 A	20-04-1993
EP 0593186 A	20-04-1994	FI 924611 A	13-04-1994
		JP 6318895 A	15-11-1994
		US 5835526 A	10-11-1998

THIS PAGE BLANK (USPTO)